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Parasitoid wasps associated with *Antigastra catalaunalis* (Lepidoptera, Crambidae) in Northern Sinaloa, Mexico

Ramón A. Sarazú-Pillado[1], Héctor González-Hernández[1], J. Refugio Lomeli-Flores[1], Jorge M. Valdez-Carrasco[1], Edgardo Cortez-Mondaca[2], Ariel Guzmán-Franco[1]

1 *Colegio de Postgraduados, Posgrado en Fitosanidad, Programa de Entomología y Acarología, Montecillo, CP 56230, Texcoco, Estado de México, Mexico* **2** *INIFAP-Campo Experimental Valle del Fuerte, Km 1609 carretera Internacional México-Nogales, Juan José Ríos, Sinaloa, 81110, Mexico*

Corresponding author: J. Refugio Lomeli-Flores (jrlomelif@hotmail.com)

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Abstract

New records of Hymenoptera parasitoids of the sesame webworm, *Antigastra catalaunalis* Duponchel (Lepidoptera: Crambidae), are presented for Northwest Mexico. Taxonomic assignation was based on morphological features. Partial sequences of the COI region from the most common parasitoids were deposited in GenBank. Six species of wasps were obtained: *Bracon* (*Habrobracon*) *platynotae* Cushman (Braconidae), *Eiphosoma dentator* Fabricius (Ichneumonidae), *Perilampus platigaster* species group (Perilampidae), *Brachymeria annulata* Walker, *Conura side* Walker, *Conura maculata* Fabricius (Chalcididae) and *Goniozus punctaticeps* Kieffer (Bethylidae). Partial sequences of the COI region obtained from the most common parasitoids helped to confirm at genus level but not species. This is the first record of the association of all these parasitoid species with *A. catalaunalis*.

Keywords

Braconidae, Chalcididae, molecular biology, Sesame webworm

Introduction

The sesame webworm, *Antigastra catalaunalis* Duponchel (Lepidoptera: Crambidae), is native in the tropical and subtropical areas of Africa, although it was first reported in South America on sesame crops (Hallman and Sanchez 1982), and it has recently

established in North America (Sarazú-Pillado et al. 2020). The second instar larva produces silk with which it binds leaves, branches, and flowers to form a shelter to protect itself from adverse abiotic conditions such as temperature and natural enemies, including parasitoids and predators (Simoglou et al. 2017). It is considered as a pest as it feeds on most parts of the plant except the root, and generally, it attacks the crop since the seedling stage (Gebregergis et al. 2016; Sarazú-Pillado et al. 2020).

Antigastra catalaunalis is a significant pest of sesame in the main producing countries in Asia and Africa. Gupta et al. (2002), reported losses from 6.2 to 43.1% in Madhya Pradesh, India; while Simoglou et al. (2017), in Drama, Northern Greece, reported losses exceeding 50% of production, with 80% of plants infested and 50% of capsules damaged. In South America, this pest was first detected in Colombia in 1971 (Hallman and Sanchez 1982). Recently, according to Sarazú-Pillado et al. (2020), it was found in Sinaloa, the main sesame-producing state in Mexico.

Currently, chemical control is the most widely used tactic against *A. catalaunalis*. However, its use also results in an imbalance in agroecosystems, environmental contamination, and a negative impact on beneficial fauna. There are 39 species of parasitoids associated with *A. catalaunalis* (Table 1), some of them are present in India (Jakhmola 1983; Naveen et al. 2019), Tanzania (Robertson 1973), Nigeria (Chadha 1974), and Colombia (Hallman and Sanchez 1982). Although, few of these parasitoids have been proposed for augmentative biological control programs, a strategy that may imply laboratory rearing and periodic mass release of the parasitoid species; for example, *Elasmus* sp. (Eulophidae) in Vietnam (Tung et al. 2011); *Trathala flavoorbitalis* Cameron (Ichneumonidae) in India (Baskaran and Thangavelu 1990); and *Bracon* (*Habrobracon*) *hebetor* Say (Braconidae) in Egypt (El-Basha 2015). However, it is necessary to identify, by morphological and molecular taxonomy, parasitoid that could be associated to *A. catalaunalis* in sesame field in northern Sinaloa, Mexico.

Materials and methods

Field collections

The collections were carried out from August to October 2020, in commercial sesame fields in the municipalities of El Fuerte (26°16'20"N, 108°54'49"W), Sinaloa (25°44'9"N, 108°15'30"W), and Mocorito (25°29'50"N, 107°53'42"W), where the highest sesame production in the state of Sinaloa is concentrated. Through the experiments these fields were under agronomic management by the producer. In El Fuerte, the Pata de Gallo variety was used, which was planted on residual moisture on July 21, 2020, with a row spacing of 80 cm and 17 plants per linear meter. A tractor was used for soil cultivation 33 days after planting for soil movement and weed elimination. An aerial application of insecticide against the sesame webworm was applied 45 days after planting, at a rate of 500 ml of Chlorpyrifos + 300 ml of Lambda Cyhalothrin/ha.

Table 1. Records of parasitoids associated with *Antigastra catalaunalis* around the world.

Order: Family Species	Distribution	References
Hymenoptera: Ichneumonidae		
Charops sp.	Tanzania	(Robertson 1973).
Diadegma sp.	India	(Jakhmola 1983; Nair 1986; Patel and Bhalani 1989).
Doliphocerus gricilis Hayat	India	(Din-Gurs and Husain 1997).
Eriborus sp.		(Ramakrishna 1927; Jakhmola 1983; Naveen et al. 2019).
Eriborus trochanteratus (Morley)	India	(Din-Gurs and Husain 1997; Kapadia 1997).
Pristomerus sp.	Nigeria and Tanzania	(Robertson 1973; Chadha 1974).
Temelucha biguttula (Matsumura)	Bangladesh	(Biswas et al. 2001).
Trathala flavoorbitalis (Cameron)	Asia, from India to Japan, Australia and Hawaii	(Ramdas-Menon et al. 1960; Jakhmola 1983; Choudhary et al. 1986; Kalra 1989; Baskaran and Thangavelu 1990; Kumar and Goel 1994; Behera 2011; Naveen et al. 2019).
Hymenoptera: Braconidae		
Agathidinae undetermined	India	(Naveen et al. 2019).
Agathis sp.	India	(Jakhmola 1983).
Apanteles sp.	India, Tanzania, and Nigeria	(Robertson 1973; Chadha 1974; Choudhary et al. 1986; Kalra 1989; Kumar and Goel 1994).
Apanteles aethiopicus Wilkinson	West Africa, Cameroon, and Somalia	(Wilkinson 1931, 1932; Walker 1994).
Bassus sp.	India	(Naveen et al. 2019).
Bassus antigastrae Wilkinson	Sudan	(Wilkinson 1931).
Bracon sp.	Colombia	(Hallman and Sanchez 1982).
Bracon (*Habrobracon*) *brevicornis* Wesmael	West and South Africa, the Middle East, India, and Europe	(Shenefelt 1978).
Bracon (*Habrobracon*) *gelechiae* Ashmead	India	(Jakhmola 1983).
Bracon (*Habrobracon*) *hebetor* Say	Egypt, India, Cosmopolitan	(Negi et al. 1944; Jakhmola 1983; Nair 1986; Patel and Bhalani 1989; El-Basha 2015; Naveen et al. 2019).
Camptothlipsis luteostigmalis van Achterberg	United Arab Emirates	(van Achterberg 2011).
Chelonus curvimaculatus Cameron	India, Sudan, West and Southern Africa	(Risbec 1950).
Hormius sp.	Senegal	(Risbec 1960).
Phanerotoma sp.	India	(Kumar and Goel 1994; Naveen et al. 2019).
Phanerotoma hendecasisella Cameron	India, Egypt, Australia, Sri Lanka, Java and Myanmar	(Bhatnagar and Davies 1979; Nair 1986; Patel and Bhalani 1989).
Hymenoptera: Chalcididae		
Brachymeria sp.		
Conura sp. (Spilochalcis)	Colombia	(Hallman and Sanchez 1982).
B. nigricorporis Husain & Agarwal	India	(Din-Gurs and Husain 1997).
Hymenoptera: Eulophidae		
Elasmus sp.	Vietnam	(Tung et al. 2011).
Elasmus brevicornis Gahan	India	(Nair 1986; Kalra 1989; Patel and Bhalani1989; Kumar and Goel 1994).
Euplectrus sp.	Colombia	(Hallman and Sanchez 1982).
Tetrastichus sp.	India	(Din-Gurs and Husain 1997).
Hymenoptera: Trichogrammatidae		
Trichogramma chilonis Ishii	India	(Choudhary et al. 2017).
Trichogramma sp.	India	(Choudhary et al. 1986).
Hymenoptera: Scelionidae		
Telenomus thestor Nixon	Uganda	(Risbec 1960).
Diptera: Tachinidae		
Cadurcia lucens Villeneuve	Nigeria	(Chadha 1974).
Exorista ebneri Villeneuve	Egypt, Sudan y Tunisia	(Risbec 1950).
Pseudoperichaeta laevis Villeneuve	Tanzania	(Robertson 1973).
Tachina sp.	Somalia	(Risbec 1960).
Zygobothria sp.	India	(Choudhary et al. 1986).

In the Sinaloa field, the Breve Doble variety was used, which was planted using residual moisture on July 19, 2020, with a row spacing of 75 cm and 17 plants per linear meter. Soil cultivation was carried out 23 days after planting for soil movement and weed elimination. No insecticide applications were made in this field.

In Mocorito, the Breve Doble variety was planted under residual moisture on July 21, 2020, with a row spacing of 75 cm and an average of 18 plants per linear meter. Soil cultivation was carried out 25 days after planting for soil movement and weed elimination. Additionally, two applications of insecticide against *A. catalaunalis* were made using a tractor. The first application was made 22 days after planting at a rate of 500 ml/ha of Emamectin Benzoate, and the second application was made 37 days after planting, using the same product and dose.

Seven samplings were made on each commercial sesame field. On each experimental field, five points were selected, one on each corner and one in the center of the field, and from each point, 35 plants were randomly selected for examination. Larvae and pupae of *A. catalaunalis* were collected from each plant. The larvae were placed in a plastic container (30 cm × 30 cm × 20 cm) covered with organza fabric with sesame leaves as food. The pupae were collected with plant tissue attached to avoid damage. Once in the laboratory, the larvae were individually placed in Petri dishes (15 cm × 2 cm) with sesame leaves as food, the pupae were separated from the plant tissue and individually placed in Petri dishes. All Petri dishes were kept at room temperature of 29 ± 4 °C, 76 ± 23% relative humidity, and a 12:12 h (light-dark) photoperiod. The material was checked daily for evidence of parasitism. The emerging parasitoids were preserved with 70% ethanol in 1.5 ml Eppendorf tubes and transferred to the Biological Control Laboratory at the Colegio de Postgraduados, Montecillo Campus, for identification.

Identification of parasitoids

The parasitoids were dehydrated in graded alcohols (80, 90, and 96%) and then placed in amyl acetate for 24 hours before being dry mounted. Photographs of the diagnostic structures (head, antennae, wings, thorax, and abdomen) and the general appearance of the adults were taken using a Carl Zeiss Discovery V20 stereoscopic microscope (White Plains, NY, USA) equipped with a Canon EOS 5D Mark II camera (Ōta, Tokyo, Japan). The images were edited using GLIMP software (version 2.10.24, free software) and stacked using ZERENE STACKER software (version T2021, Zerene Systems LLC). Morphological identification of the adults was carried out using the follow identification keys: for Braconidae Cushman (1914) and Goulet and Huber (1993); for Bethylidae Evans (1979); for Ichneumonidae Dasch (1979) and Gauld (2000); for Perilampidae Darling (1997); and for Chalcididae Boucek and Halstead (1997). Experts in each taxonomic group confirmed species identifications. Taxa names of Ichneumonoidea are according to Yu et al. (2016). Reference specimens of the parasitoids and adults of *A. catalaunalis* were deposited in the entomological collections of the Colegio de Postgraduados (CEAM) and the MIFA, Faculty of Engineering and Sciences, Universidad Autónoma de Tamaulipas, Cd. Victoria, Tamaulipas, Mexico (MIFA-UAT).

DNA extraction and COI amplification

DNA extractions from the parasitoids were performed using the Quick-DNA Tissue/Insect Miniprep Kit (Zymo Research), following the manufacturer's instructions. Quality and quantity of the extracted DNA were determined by visualization on agarose gels and using the NanoDrop, respectively.

PCR reactions to amplify a 650–700 bp region of the cytochrome oxidase subunit I (COI) gene were performed using the HCO-2198 primers (TAA ACT TCA GGG TGA CCA AAA AAT CA) and LCO-1490 (GGT CAA CAA ATC ATA AAG ATA TTG G) (Hebert et al. 2003). For a final reaction volume of 30 µL, 3 µL of buffer (10X), 1.2 µL of $MgCl_2$ (25 mM), 0.6 µL of dNTPs (10 mM), 0.9 µL of each primer (10 µM), 0.1 µL of Taq polymerase (5 U µL-1), 5 µL of DNA (10–20 ng µL-1), and 18.3 µL of 6% trehalose were used. The thermal conditions for amplification were as follows: an initial denaturation step of 60 sec at 94 °C; followed by five cycles of 60 sec at 94 °C, 90 sec at 45 °C, and 90 sec at 72 °C, then 35 cycles of 60 sec at 94 °C, 90 sec at 60 °C, and 60 sec at 72 °C, ending with a final extension of 5 min at 72 °C. The PCR products were visualized on an agarose gel and photographed using the Infinity VX2 System device (Vilber Lourmat, France). The PCR products were sent to the Company Macrogen (Seoul, Korea) for sequencing. The resulting sequences were edited using BioEdit v. 7.1.9. The sequences were compared against the GenBank database using the BLAST search engine. From the BLAST results list, the species with the highest score, 98–100%, was used to assign species, or 93–98% to assign the higher taxon group (Hebert et al. 2003). COI sequences obtained were deposited in GenBank, and the accession numbers are indicated in Table 2.

Table 2. Relationship of parasitoids of *Antigastra catalaunalis* collected in three municipalities of Northern Sinaloa, Mexico.

	Localities							Total specimen	Total Localities
	Mocorito		El Fuerte		Sinaloa				
Collection date	**1**	**4**	**2**	**6**	**3**	**5**	**7**		
Parasitoid species (PS)									
*Brachymeria annulata**	-	2	-	1	1	-	2	6	4
Bracon (*Habrobracon*) *platynotae**	-	8 (2)	10 (3)	7 (2)	4 (1)	3 (2)	7 (2)/ MZ196440 MZ196441 MZ196442 MZ196443	39(12)	6
*Conura maculata**	-	-	2	2	-	1	3	8	4
*Conura side**	-	-	1	-	1	-	1	3	3
*Eiphosoma dentator**	-	2/MZ196444	1	-	1/MZ196445	1	-	5	4
*Goniozus punctaticeps**	-	-	4 (1)	3 (1)	-	4 (1)	4 (1)	15 (04)	4
Perilampus platigaster species group*	-	1	-	-	-	-	-	1	1
Total specimens	0	13 (2)	18 (4)	13 (3)	7 (1)	9 (3)	17 (3)		
		13 (2)	31 (7)			33 (7)		77 (16)	

*New record association host-parasitoid; Collection date (2020): 1) 13/VIII, 2) 19/VIII, 3) 21/VIII, 4) 22/VIII, 5) 12/IX, 6) 26/IX, 7) 27/IX; Number of specimens: The number of parasitized *A. catalaunalis* immature stage is noted in parentheses; GenBank access number: MZ196440 to MZ196445.

Results

In the present study a total of 77 parasitoid specimens from seven species were obtained associated to *A. catalaunalis* in commercial sesame fields of Sinaloa. Among these, three species emerged from larvae and four from pupae. The highest number and diversity of parasitoids were found in the municipalities of Sinaloa and El Fuerte, with six species each, while four species were collected in Mocorito. *Bracon* (*Habrobracon*) *platynotae* Cushman (Braconidae) was the most abundant species (39 specimens), followed by *Goniozus punctaticeps* (Bethylidae) (15 specimens), *Conura maculata* (Chalcididae) (8 specimens), *Brachymeria annulata* (Chalcididae) (6 specimens), *Eiphosoma dentator* (Ichneumonidae) (5 specimens), *Conura side* (Chalcididae) (3 specimens), and *Perilampus platigaster* species group (Perilampidae) (one specimen).

When the obtained sequences were compared to the GenBank database, no similarity above 98% was obtained, which could have helped to confirm species. However, for the sequences of *E. dentator*, the closest match was with a sequence of *E. tantalium* (JF793018.1) with a 91.32% identity, an E-value of 0.0 and 95% query cover, which confirmed the correct genus identification. For the sequences of *B. platynotae*, the closest match obtained was 92.24% similarity with a sequence of *Habrobracon* sp. (MG439564.1), an E-value of 0.0 and 95% query cover, confirming the correct genus identification.

Discussion

The species complex of parasitoids associated with *A. catalaunalis* in northern Sinaloa (Fig. 1) could be an important component for the integrated management of this pest in sesame. Below are some details of the collected species.

Bracon (*Habrobracon*) *platynotae* Cushman (Braconidae) (Fig. 1C, D) was the most abundant parasitoid species from the three municipalities, except for one collection date in Mocorito, where the parasitoid was absent, possibly due to insecticide application before collection. Up to four parasitoid adults were obtained from a single *A. catalaunalis* larva, indicating it is a gregarious ectoparasitoid (Table 2). Although it only parasitizes large larvae of the 4th and 5th instars, it was observed to cause permanent paralysis and death of small larvae, possibly for feeding, like what was observed with *B. hebetor* on *A. catalaunalis* larvae, in Egypt (El-Basha 2015). This species has only been reported in Mexico on *Pectinophora gossypiella* Saunders (Gelechiidae), under the synonym *Microbracon platynotae* Cushman, in Durango (Muesebeck 1925). This study reports for the first time *B. platynotae* as a parasitoid of *A. catalaunalis* in Sinaloa, Mexico. Given that several species of the subgenus *Habrobracon* have shown success in biological control programs, *B. platynotae* would be a viable option for laboratory and field evaluation studies; considering that it also has *P. gossypiella* as host (Muesebeck 1925).

Goniozus punctaticeps Kieffer (Bethylidae) (Fig. 1E, F) is a gregarious ectoparasitoid of lepidopteran larvae (Evans 1979). It was found in the municipalities of El Fuerte and Sinaloa, with up to four adults obtained from one *A. catalaunalis* larva (Table 2). The parasitized larvae exhibited permanent paralysis. This parasitoid has been reared

in Texas, USA on *Acrobasis nuxvorella* Neunzig (Pyralidae) and *Cidia caryana* Fitch (Tortricidae) on pecan (Nickels et al. 1950), also in *Coleotechnites* (=*Evagora*) *milleri* Busck (Gelechiidae), *C.* (=*Lespeyresia*) *caryana*, *A. nuxvorella* and *Etiella zinckenella* Treitschke (Pyralidae) also in the USA (Evans 1979). In Mexico, *G. punctaticeps* (cited as *P. cellularis*) has only been reported on *A. nuxvorella* and *C. caryana* in walnut trees

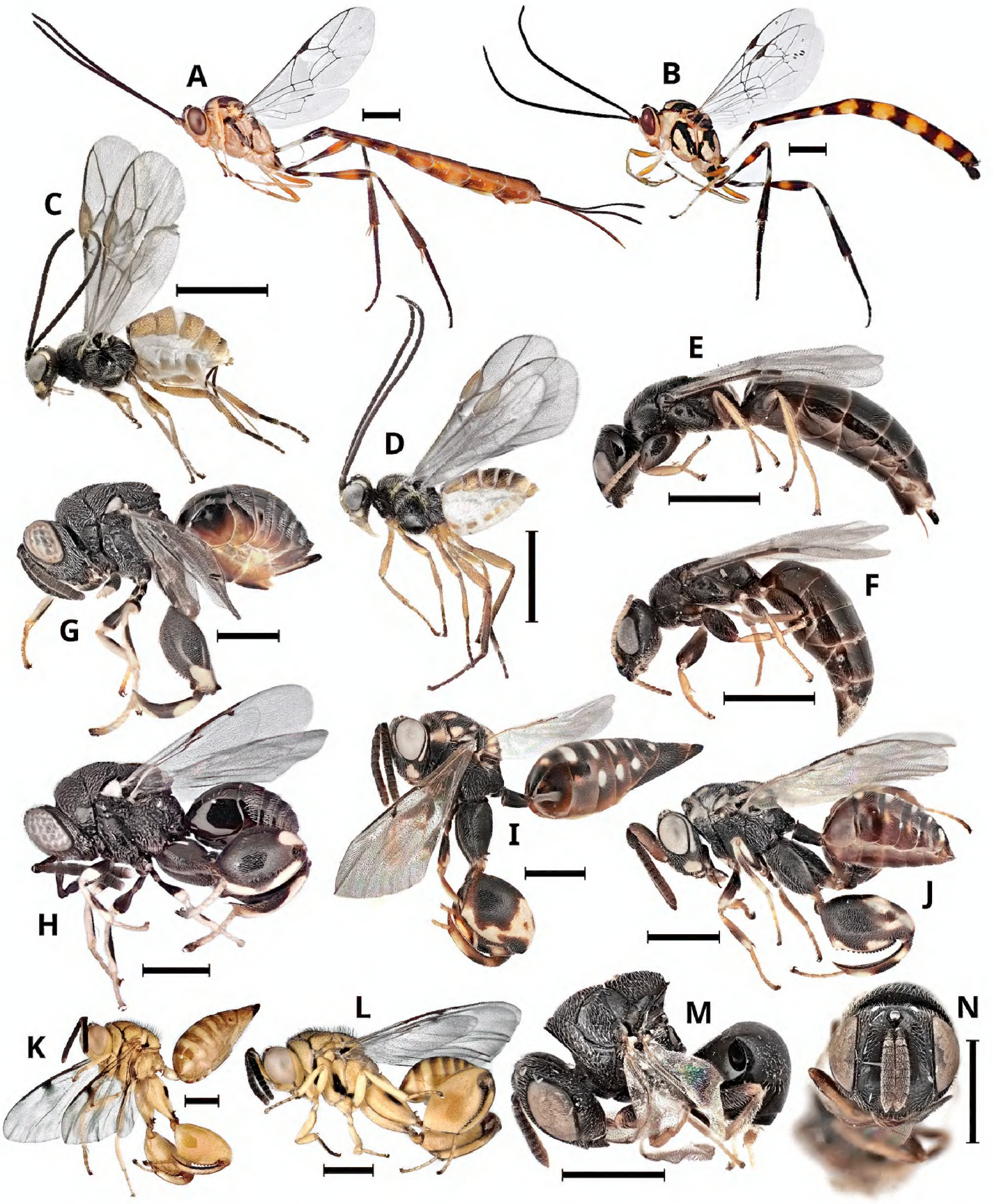

Figure 1. *Eiphosoma dentator* **A** female lateral view **B** male lateral view; *Bracon* (*Habrobacon*) *platynotae* **C** female lateral view **D** male lateral view; *Goniozus punctaticeps* **E** female lateral view **F** male lateral view; *Brachymeria annulata* **G** female lateral view **H** male lateral view; *Conura side* **I** female lateral view **J** male lateral view; *Conura maculata* **K** female lateral view **L** male lateral view; *Perilampus platigaster* species group **M** male lateral view **N** male Front view. Scale bars: 1 millimeter.

in Nuevo León (Reyes-Villanueva 1987). There are no previous records of Bethylidae species associated with *A. catalaunalis*, so *G. punctaticeps* is reported for the first time as a parasitoid on this host in northern Sinaloa, Mexico.

Eiphosoma dentator Fabricius (Ichneumonidae) (Fig. 1A, B) is a solitary ectoparasitoid of lepidopteran larvae (Dasch 1979). It was reared in all three municipalities, but in low numbers (Table 2). *A. catalaunalis* larvae parasitized by *E. dentator* exhibited permanent paralysis. It was first reported in Texas, USA, by Mann (1969), parasitizing *Loxomorpha flavidissimalis* Grote (Crambidae), a potential pest in prickly pear crops. In South Florida, USA, it was found parasitizing *Lineodes interga* Zeller (Crambidae), a pest of eggplant (Dasch 1979). In Barbados, it is also associated with a pest of the family Crambidae, such as *Diaphania hyalinata* L. (Alam 1989). Recently, it was also reported in Tamaulipas, Mexico, on *L. flavidissimalis* (Gaona-García et al. 2020). In this study, *E. dentator* is reported for the first time as a parasitoid of *A. catalaunalis* in Sinaloa, Northwest Mexico. In some studies, it is reported without major impact on pest lepidopteran populations (Mann 1969; Dasch 1979; Alam 1989; Gaona-García et al. 2020). However, based on observations in this study, this parasitoid is considered an additional regulatory factor for *A. catalaunalis* populations in sesame, which could be exploited in conservation biological control programs.

Brachymeria annulata Walker (Chalcididae) (Fig. 1G, H), adults were collected individually from *A. catalaunalis* pupae, one specimen in El Fuerte, two specimens in Mocorito and three specimens in Sinaloa municipality (Table 2). There exist records of *B. annulata* parasitizing *Talides hispa* Evans (Hesperiidae) in Panama (Santos-Murgas et al. 2021); *Erinnys ello* L. (Sphingidae) in Acre, Brazil, *Alabama argillacea* Hubner (Noctuidae) in Paraguay (Silvie et al. 2007), and as a hyperparasitoid associated with *Diadegma leontiniae* Brèthes (Ichneumonidae) in the Brasilia region, Brazil (Guilloux et al. 2002), parasitoid released in cruciferous crops. *Brachymeria* sp. (Hallman and Sanchez 1982) and *Brachymeria nigricorporis* (Din-Gurs and Husain 1997) (Table 1) are the only previous records of association between wasps of the genus *Brachymeria* as parasitoids of *A. catalaunalis*. In this study, *B. annulata* is reported for the first time as a parasitoid of *A. catalaunalis* pupae in Sinaloa, Northwest Mexico.

Three specimens of *Conura side* Walker (Chalcididae) (Fig. 1I, J) were obtained from *A. catalaunalis* pupae (Fig. 2I, H), one from El Fuerte and two from Sinaloa. As a primary parasitoid, it has been associated with some species of Chrysomelidae (Coleoptera), such as *Gratiana boliviana* Spaeth, a beetle released in Florida and other parts of the USA as a biological control agent against *Solanum viarum* Dunal (Solanaceae) (Diaz et al. 2012). It was also released in Maryland, USA, for biological control of *Cassida rubiginosa* Muller, a chrysomelid considered an invasive pest and defoliator of some *Carduus* species (Tipping 1993). As primary parasitoid it was reared from pupae of *Anagasta kuhniella* Zeller and *Galleria mellonella* L. (Pyralidae) in Belleville, Canada (Arthur 1958). As a hyperparasitoid it was collected on *Campoletis sonorensis* Cameron, parasitoid of important pests of maize (Vinson and Iwantsch 1980); also, on *Diadegma insulare* Cresson on cruciferous pests (Lee and Heimpel 2005).

Conura maculata Fabricius (Chalcididae) (Fig. 1K, L) was collected as a solitary parasitoid in *A. catalaunalis* pupae, with four specimens in El Fuerte and Sinaloa, respectively (Table 2). As a primary parasitoid, it has been reported on chrysalids of *Opsiphanes invirae*

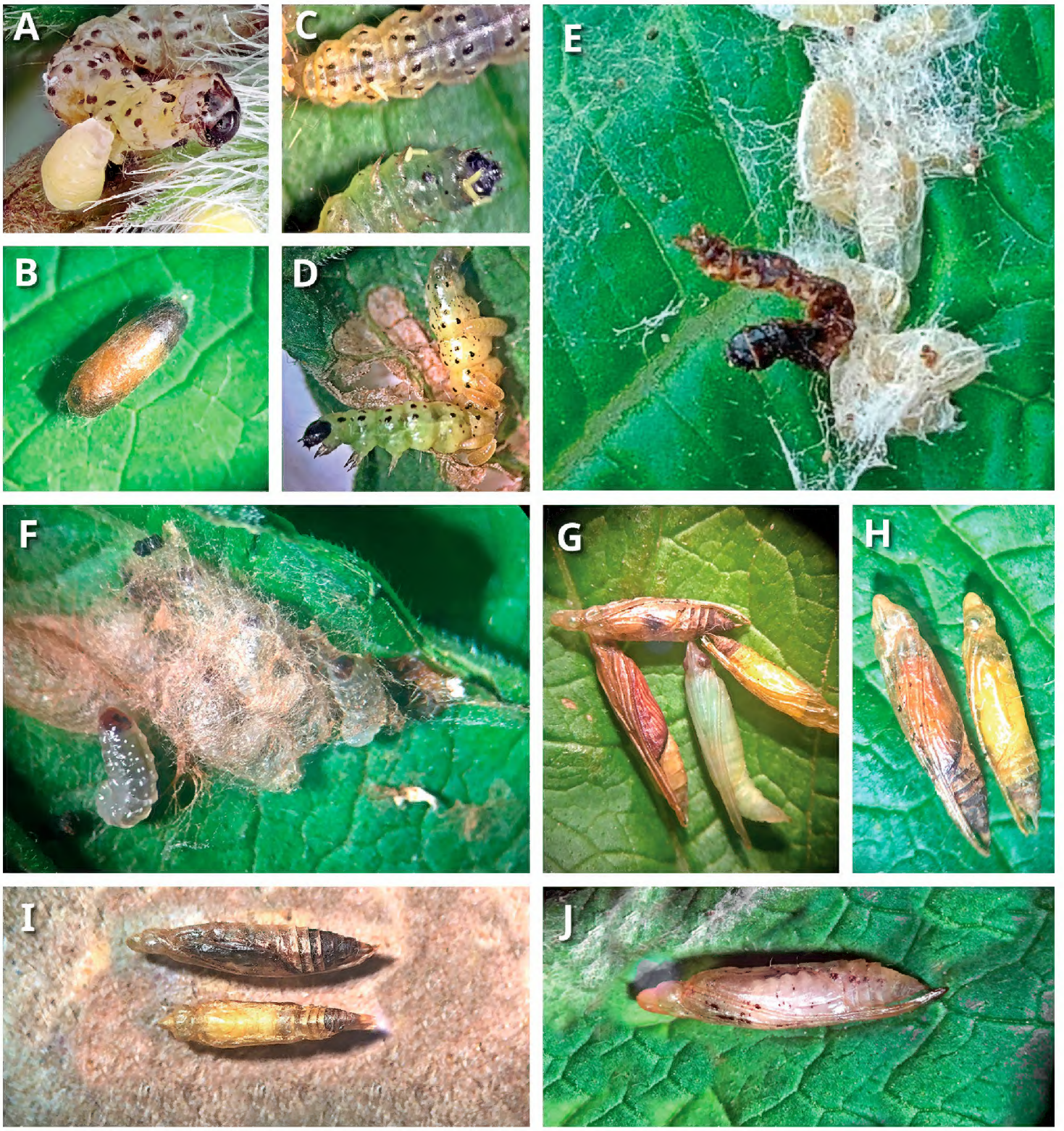

Figure 2. *Eiphosoma dentator* **A** larva feeding on an *Antigastra catalaunalis* larvae **B** cocoon; *Bracon* (*Habrobracon*) *platynotae* **C** eggs **D** larvae on *A. catalaunalis* larva; **E** cocoon **F** *Goniozus punctaticeps* larvae and cocoon on *A. catalaunalis* larvae; *C. maculata* **G** healthy pupae of *A. catalaunalis* (below) and pupae parasitized **H** parasitized pupae; *Conura* spp. **I** pupae parasitized by *C. side* (above) *C. maculata* (below); *C. side* **J** pupae of *A. catalaunalis* parasitized.

amplificatus Stichel, a pest of palm oil in Argentina (Gervazoni and Arbino 2018), and Rio Grande do Sul, Brazil (Salgado-Neto and Lopes-Da-Silva 2011). *Conura maculata* has been recorded as a hyperparasitoid on *Cotesia rubecula* Marshall and *C. glomerata* L. (McDonald and Kok 1991). This parasitoid species is widely recorded in America, mostly from tropical areas (Delvare 1992). Özdikmen (2011), noted that *C. maculata* is distributed from Mexico to Paraguay. Recently, Huber et al. (2021), reported the presence of *C. maculata* in Canada and the USA. *Conura* (=*Spilochalcis*) sp. (Hallman and Sanchez 1982) was the only record of association between this genus of parasitoid wasp on *A. catalaunalis* in

Colombia (Table 1). Thus, in the present study, the association of *C. side* and *C. maculata* with *A. catalaunalis* in sesame in Sinaloa, Northwest Mexico, is reported for the first time.

Only one specimen of *Perilampus platigaster* species group (Smulyan 1936), (Perilampidae) (Fig. 1M, N), was obtained in Mocorito (Table 2). Members of this genus are known to be hyperparasitoids, mainly of Tachinidae (Diptera) and Ichneumonoidea (Hymenoptera) (Darling 1997). This is the first report of *Perilampus platigaster* species group associated with *A. catalaunalis* pupae.

The lack of sequences of *E. dentator* and *H. platynotae* in the GenBank database, did not allow a molecular confirmation at the species level; however, it helped to confirm the genus, and because these sequences were deposited in this database, they can be used as references in future research on this species.

Conclusions

Among the three species of *A. catalaunalis* larval parasitoids, only *Bracon* (*Habrobracon*) *platynotae* was more abundant in all three collection sites and throughout the crop cycle (Table 2), with a higher presence in August, consistent with the population peaks of *A. catalaunalis*. This parasitoid has attributes that could position it as a candidate for mass-rearing studies and for use as a biological control agent. In this study, no apparent hyperparasitism was found on its larvae, nor on the larvae of the other larval parasitoids such as *Goniozus punctaticeps* and *Eiphosoma dentator*. The most abundant pupal parasitoids were *Conura maculata* and *Brachymeria annulata*. The four wasps reared from pupae also can act as hyperparasitoids of Ichneumonoidea (Hymenoptera) and Tachinidae (Diptera). In this study, all specimens of the families Chalcididae were obtained from *A. catalaunalis* pupae, and it is very likely that *Perilampus platigaster* species group is a hyperparasitoid of the collected Ichneumons, due to the background we have on this species group.

The obtained results offer alternatives for using several parasitoid species in an integrated management program for sesame cultivation in Sinaloa, Mexico. This includes the proposal of using *B. platynotae* as a biological control agent through augmentation, or the use of the parasitoid complex in conservation strategies for beneficial parasitoid and predator fauna.

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